U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE

HEARING CHARTER

NASA's Science Mission Directorate: Impacts of the Fiscal Year 2007 Budget Proposal

March 2, 2006
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Purpose

On Thursday, March 2, at 10 a.m., the House Committee on Science will hold a hearing to review the proposed fiscal year 2007 (FY07) budget for the Science Mission Directorate of the National Aeronautics and Space Administration's (NASA), and to examine how that budget would affect research in space science and earth science.

The proposed budget for science is a controversial aspect of NASA's FY07 budget request because it would result in the cancellation or delay of a number of missions and provides little funding for the initiation of any missions beyond those already in the queue for development or launch.

Witnesses

Dr. Mary Cleave is the Associate Administrator at NASA for the Science Mission Directorate.

Dr. Fran Bagenal is a member of the National Academy of Sciences Decadal Survey for Sun-Earth Connections, "The Sun to the Earth and Beyond" (2003). Dr. Bagenal is a Professor of Astrophysical and Planetary Sciences at the University of Colorado at Boulder.

Dr. Wes Huntress is a member of the National Academy of Sciences Decadal Survey for Solar System Exploration, "New Frontiers in the Solar System" (2003). Dr. Huntress is the Director of the Geophysical Laboratory at the Carnegie Institution of Washington and was Associate Administrator for Space Science at NASA from 1992 to 1998.

Dr. Berrien Moore is the Co-Chairman of the National Academy of Sciences Decadal Survey for Earth Sciences, "Earth Observations from Space: A Community Assessment and Strategy for the Future" (expected fall 2006). Dr. Moore is the Director for the Institute for the Study of Earth, Oceans, and Space at the University of New Hampshire.

Dr. Joseph H. Taylor, Jr. is the Co-Chairman of the National Academy of Sciences Decadal Survey for Astrophysics, "Astronomy and Astrophysics in the New Millennium"

(2001). Dr. Taylor is a Nobel Laureate and Distinguished Professor of Physics at Princeton University.

Overarching Questions

The Committee plans to explore the following overarching questions at the hearing:

1. How did NASA determine its science priorities for the FY07 budget? To what extent are NASA's priorities based on the decadal surveys in which scientists determine the priorities for their fields? Do those surveys need to be redone now that science funding may be lower than was expected?

2. What impact would the proposed science budget have on the research agenda of space and earth scientists? What technological advances and scientific discoveries may be delayed or foregone and how significant a loss would that be?

3. To what extent would the proposed FY07 budget make it difficult to attract or retain students or researchers in the space and earth sciences? What steps can be taken to ensure that these fields remain healthy in an era of budgetary constraints?

4. Has NASA provided an appropriate amount of money for science in its FY07 budget request, given the competing needs of science, aeronautics, the Space Shuttle and International Space Stations programs and the Vision for Space Exploration?

Brief Overview

The Budget

Under the Administration's proposal, spending for NASA's Science Mission Directorate would increase by 1.5 percent in FY07, to about $5.3 billion, which is about one-third of the total requested spending for all of NASA. The proposal projects 1 percent annual increases for the Science Mission Directorate in FY08 - FY11. (Inflation is projected to increase at about 3.3 percent in FY07.)

This is a significant turnabout from what was projected a year ago. In its FY06 budget request, the Administration projected that spending on the Science Mission Directorate would increase by about 7 percent in FY07 and that the Directorate would experience further strong growth in the four ensuing years.

All told, the FY07 budget request provides $3.1 billion less for the Science Mission Directorate for FY06 through FY10 than what had been projected as part of the FY06 budget request. NASA Administrator Michael Griffin testified on Feb. 16 that the money that was to have been spent on science would be used instead to fund the Space Shuttle program, which had been underfunded in the FY06 budget request projections. (Portions of the Exploration account were also reduced from earlier projected levels to cover

Shuttle costs.) The cuts from the levels projected in FY06 will necessitate the cancellation or delay of missions and will make it difficult to initiate the formulation of any new missions. (Each mission spans many years from development through launch and operation.)

The Science Mission Directorate has also had to reassess its research agenda because of cost growth in several of it missions. The reason for this growth varies by mission: in some cases, original estimates were too optimistic about how difficult it would be to develop the technology; in other cases, policy changes have resulted in a change in the purpose or nature of the mission. (The specific cases are discussed below.)

The Programs

The Science Mission Directorate supports research in four major areas, each of which would see its program scaled back in the FY07 budget. Research in **Solar System Exploration or Planetary Sciences** seeks to understand the nature of the other planets in our solar system as well as moons, asteroids, comets through launching orbiters, rovers and other landers, and fly-by missions. Research in **Astrophysics** seeks to understand the origins of the universe, the physical laws of the universe, the nature of matter and energy and other aspects of astronomy through orbiting space telescopes and other space-based instruments. Research in **Heliophysics** or **Sun-Earth Connections** seeks to understand the impacts of the Sun on the solar system (including such phenomena as the solar wind and solar flares) through spacecraft-based sensors. Research in **Earth Science** seeks to understand the Earth's land, atmosphere and oceans and the interactions among them through satellites that orbit the Earth.

In each of these areas, the Directorate funds three types of activities, all of which would be scaled back. First, it funds major, flagship missions that require the cooperation of many scientists from NASA centers, universities and other research institutions to design, develop and operate. These missions are selected by NASA based on recommendations in scientific decadal surveys (see below). Second, it funds smaller, briefer, lower-cost missions that are selected through competitive peer review and that involve fewer institutions. Third, the Directorate funds research grants to scientists to study the data obtained by the missions through its Research and Analysis (R&A) programs. R&A funding is generally awarded through competitions.

The Scientific Community

Unlike what happens in most fields of science, scientists in the fields supported by NASA get together every decade to agree on the priority missions necessary to keep their fields moving forward. These "decadal surveys" are conducted under the auspices of the National Academy of Sciences (NAS) using funds from NASA. The non-NASA witnesses at the hearing participated in, or led (or are leading) the most recent decadal surveys in their fields.

The most recent surveys were completed for Sun-Earth Connections (projects currently within the "Earth-Sun System" division) in 2003, Solar System Exploration in 2003, and Astrophysics (the "Universe" division) in 2001. The Survey for Earth Sciences is currently being conducted. The interim report was released in April 2005 (and discussed at a Science Committee hearing shortly thereafter), and the final report is due in late 2006.

The decadal surveys are not based on any particular budget assumptions. The surveys do sometimes prioritize missions in different cost tiers rather than simply providing a single list of priorities.

Federal agencies

Other federal agencies fund research in the fields supported by NASA. The National Science Foundation (NSF) funds ground-based telescopes that are also used for astronomy and astrophysics. NASA and NSF appoint a joint advisory committee on astronomy and astrophysics as required by the *National Science Foundation Act of 2002*. The National Oceanic and Atmospheric Administration (NOAA) also supports earth satellite missions. Generally, NOAA's missions are for ongoing operational purposes, in contrast to NASA's time-limited research missions. NASA often develops new technology for its missions that is later put to use by NOAA after it has proved successful. The *NASA Authorization Act of 2005* requires greater coordination and joint reporting by NASA and NOAA. The Department of Energy (DOE) Office of Science funds basic research at colliders and other facilities on the nature of matter that is relevant to some of the questions NASA explores in astrophysics. NASA and DOE are working together on a Joint Dark Energy Mission.

Programmatic Details

Across the Directorate

Several reductions from previous plans are common to all the programs in the Science Mission Directorate. The cuts that are proposed across the Directorate have drawn the loudest criticism from the scientific community because they would have a widespread impact on researchers and students.

Funding for the smaller, lower-cost, competitively selected missions are cut throughout the Directorate. These missions, with their shorter development time, have been particularly important in training graduate students and other future scientists, as well as for rapidly addressing specific emerging scientific questions. The smaller mission programs include Explorer in the Solar System Exploration and Earth-Sun System divisions; Discovery in the Solar System Exploration division; and the Earth System Science Pathfinder (ESSP) program. Missions in these programs would be selected less frequently under the proposed FY07 budget. In the past, new missions were generally selected every two to three years. The FY07 budget would lengthen the gap between missions. For example, in the Earth Science program, the last new Pathfinder mission

was selected in 2002, and, under the proposed budget, the next one is projected to be chosen no earlier than FY08.

In addition, funding for R&A was cut by 15 to 20 percent in each of the Directorate's fields on top of a reduction in FY06. The R&A account provides funds to scientists to perform research on the data collected by the various missions. NASA argues that less money is needed for R&A because fewer new missions will be launched. But there is a backlog of existing data, and R&A is the primary source of ongoing funding for academic scientists and their students in the fields supported by NASA. (Mission funding is largely eaten up by the cost of building and operating the instruments being flown.)

Solar System Exploration

Solar System Exploration is increased slightly (to $1.61 billion) compared to FY06 after sustaining significant cuts in FY06. That cut in FY06 resulted from the cancellation of several robotic missions to Mars that were intended more as precursors to a human mission than as scientific expeditions. In addition, Solar System Exploration would absorb the majority of the reductions from the projected spending that had been included in the FY06 budget proposal. From FY06 through FY10, the proposed FY07 budget provides $2.99 billion less than would have been spent under the FY06 projections. That cut also is largely due to the elimination of the Mars missions, which would have required continued spending over the period. NASA points out that even with these cuts, a new mission to Mars will be launched every 26 months. NASA also continues to operate several ongoing Mars missions, including the twin Mars rovers Spirit and Opportunity.

The scientific community has not raised loud objections to the revamped Mars program as most of the missions that were cancelled were not primarily designed for scientific purposes. The cancelled missions include the Mars Telecommunications Orbiter, two Mars testbed missions, and future Mars human precursor missions. The Mars Sample Return mission to robotically bring back soil samples from the Martian surface is indefinitely deferred in the FY07 budget proposal.

Another impact of the reduced spending on Solar System Exploration is that the program will not be launching a new, large, flagship mission for at least 10 years. (The recently launched mission to Pluto, New Horizons, does not qualify because it is a less elaborate mission that will just fly by Pluto and was developed differently.) No flagship mission could launch for at least a decade because there is no such mission in development and no funds are provided in the FY07 budget runout to begin development on one. Previous flagship missions have included the Cassini mission to Saturn, the Galileo mission to Jupiter, and the Viking mission to Mars.

The highest-ranked mission in the most recent decadal survey for Solar System Exploration is a mission to Europa, a moon of Jupiter that may have, or may have had in the past, liquid water. NASA has started work on a Europa mission in the past, but then has pulled back for various reasons. (The most recent effort was cancelled a couple of

years ago when a program to create a nuclear propulsion system for the mission was stopped.) There is no money in the proposed FY07-FY11 budget for a mission, although Congress directed NASA in the FY06 Science, State, Justice Commerce Appropriations Act (P.L. 109-108) to begin planning a mission to Europa and include it as part of its FY07 budget. NASA points out that a mission to Saturn's moon, Titan, that sent back data after the decadal survey may indicate that Titan would be a better target for a mission than Europa.

Also under Solar System Exploration, the FY07 budget proposal cuts the Astrobiology program by 50 percent. NASA argues that the field is less pressing because no human mission to Mars is imminent. But it is not clear why such a mission would be the sole or even the primary reason to study the origins, evolution, distribution, and future of life in the universe, or the search for potentially inhabited planets beyond our Solar System.

Solar System Exploration also received the largest reduction to R&A of all the NASA Science divisions because of the significant cut in its overall missions rate and budget.

Astrophysics (which NASA sometimes calls "Universe")

Under the proposed FY07 budget, Astrophysics would see a small increase of about $2 million to $1.51 billion and then would begin to decline in FY08, ending in FY11 at about $1.31 billion. The total proposed over FY06-FY10 is about $380 million less than what had been projected in the FY06 budget proposal.

Astrophysics also would defer and may cancel several missions under the FY07 proposal. But in addition to the overall budget, Astrophysics needs to contend with significant cost overruns in a number of its missions, including its top priority, the James Webb Space Telescope (JWST), the follow-on to the Hubble Space Telescope. The FY07 budget also includes money for the servicing mission to the Hubble (excluding the cost of the Shuttle launch itself), which had not been included in the FY06 budget plan. Overall, funding has been provided for the large, long-term priorities like Webb and Hubble, while projects that were to begin development in the next several years, such as the search for extra-solar planets and the study of "dark energy," have been deferred.

NASA is planning a Shuttle mission to service the Hubble in 2008, assuming the next Shuttle flight shows the vehicle can operate safely. Over the last several years, NASA has implemented conservation measures to help extend the life of the batteries and gyros on Hubble so that it should remain operational into 2008. To pay for continued operations and preparations for the planned servicing mission, the FY07 budget increases funding for Hubble.

The FY07 proposal increases funding for JWST to cope with the projected $1 billion cost growth, and pushes back the launch two years to 2013. JWST is ranked as the top priority in the astronomy and astrophysics decadal survey. NASA is reviewing the program now, and expects to have a better handle on JWST cost estimates this spring,

which will be reflected in the FY08 budget. Under its standard review processes, NASA will not make a final decision on launching JWST until next January.

The Stratospheric Observatory for Infrared Astronomy (SOFIA) program is zeroed out in the FY07 budget, but is under review. The SOFIA observatory, a heavily modified Boeing 747 carrying an infrared telescope, is a joint program with the German Aerospace Center. The project is significantly over budget and behind schedule. SOFIA was planned to work in conjunction with the Spitzer telescope, currently in operation, but now would have little overlap with Spitzer. SOFIA is still funded in FY06, but NASA has directed that no new work be started until the review is completed. A final decision on SOFIA is expected in the next few months. If NASA decides to allow the program to proceed, it will look for cuts in other programs to find the funding.

The Navigator program, a series of ground-based and space-based telescopes used to detect planets around other stars, is cut significantly in the FY07 proposal. The programs under Navigator are the Space Interferometry Mission (SIM), the Terrestrial Planet Finder (TPF), the Keck Interferometer, and the Large Binocular Telescope Interferometer (LBTI). SIM is under review with a launch date of no earlier than 2015, pushed back from earlier projections of 2009 or 2011. TPF, which has had technical problems, has been deferred indefinitely. The Keck Interferometer is in operation, but proposed upgrades to improve performance are cancelled.

The Beyond Einstein program fares poorly in the FY07 proposal. The program would receive 66 percent less over the FY06-FY10 period than had been projected in FY06. Beyond Einstein is designed to observe phenomena predicted by theoretical physics, such as phenomena that would shed light on the Big Bang, black holes, and the existence of a "dark energy." NASA plans to proceed with studies related to the missions in FY07. Missions being studied the Joint Dark Energy Mission, which would be run in conjunction with the Department of Energy.

Earth-Sun Systems

In the FY07 budget Earth-Sun Systems is treated as a single unit, although NASA is running the programs now through two separate divisions, Heliophysics (Sun-Earth Connections) and Earth Science.

The FY07 budget for Earth-Sun Systems provides about $302 million more than had been included in the FY06 budget for the division in FY06-FY10. The total proposed funding of about $2.2 billion in FY07 would be an increase of about $50 million over FY06.

But the proposed budget has still raised scientific concerns both because the FY06 baseline was a significant drop from previous years – the interim decadal survey called it "alarming" – and because the budget must accommodate increased costs for two projects related to problems with a satellite program run by the National Oceanic and Atmospheric Administration (NOAA).

Under the proposed FY07 budget, the flagship Earth Science mission will be delayed for budgetary reasons and virtually no funding is provided for any mission not already in development.

Most of the proposed increased funding will be directed instead toward two missions connected to the problem-plagued weather satellite program, the National Polar-orbiting Operational Environmental Satellite System (NPOESS). (NPOESS, which is run jointly by NOAA, the Air Force and NASA, is currently under review because it is more than 25 percent over budget and several years behind schedule. The Science Committee held a hearing on the program last fall.) The two missions are the NPOESS Preparatory Project (NPP), a precursor to NPOESS, and the Landsat Data Continuity Mission (LDCM). NPP has been delayed significantly because of technical problems with sensor development overseen by NOAA and the Air Force, thus increasing the total cost of the program. Landsat was originally to have flown as part of NPOESS – a White House decision – but now technical problems with that arrangement and the overall problems with NPOESS have led the White House to change course and have Landsat fly as a separate mission. Landsat satellites have been circling the Earth for decades providing large-scale imagery.

The flagship Earth Science mission is the Global Precipitation Measurement (GPM) mission, a joint U.S.-Japanese project intended to improve climate and weather prediction through more accurate and more frequent precipitation measurements. It was originally scheduled for launch in 2008. In the FY07 budget plan, the launch of GPM has been delayed to 2012. In its interim report, the Earth Sciences decadal survey recommended that the GPM mission "be launched without further delays." There is a growing concern among scientists that further delays in this program could have serious consequences for the international partnership, such as the loss of Japanese support for the program.

Questions for the Witnesses

The witnesses were asked to address the following questions in their testimony:

Questions for Dr. Mary Cleave

Please briefly explain the President's FY07 budget request for NASA's Science Mission Directorate and answer the following questions:

- How did NASA decide what missions to defer or cancel in response to the reduced spending growth for the Science Mission Directorate? Was funding first allocated among the different divisions or did you begin by evaluating missions across the entire directorate? To what extent did you consult with the scientific community in determining how to distribute the available funds?
- What is NASA doing to ensure that the U.S. will continue to have a robust scientific enterprise in the fields supported by your directorate and will be able to continue to attract new students and researchers? To what extent will this be affected by the proposed cutbacks in Research and Analysis and how was the size

of those proposed cutbacks be determined? To what extent does the proposed budget allow for the initiation of new missions that are not already in the queue?
- If the directorate were to receive more funding than that in the proposed FY07 budget, what would be the first projects to be restored?
- Are there any changes you would like to see in the National Academies Decadal Survey process to help you now or in the years ahead?

Questions for Dr. Fran Bagenal

- What do you see as the most serious impacts on your field of the proposed slowed growth in the Science Mission Directorate? Clearly, it would be better to conduct more science than less, but what is the real harm in delaying specific missions? At what point do delays or cutbacks become severe enough to make it difficult to retain or attract scientists or engineers to your field?
- Do you believe the decisions NASA has made concerning which missions to defer or cancel are consistent with the most recent National Academies Decadal Survey that you released? Have there been any developments since the Decadal Survey that need to be taken into account, and has NASA considered those? Given the FY07 budget request, do you see any need to update the most recent survey or to change the process for the next Decadal Survey?
- How should NASA balance priorities among the various disciplines supported by its Science Mission Directorate? Do you believe the proposed FY07 budget, given the overall level of spending allotted to science, does a good job of setting priorities across fields?

Questions for Dr. Wes Huntress

- What do you see as the most serious impacts on your field of the proposed slowed growth in the Science Mission Directorate? Clearly, it would be better to conduct more science than less, but what is the real harm in delaying specific missions? At what point do delays or cutbacks become severe enough to make it difficult to retain or attract scientists or engineers to your field?
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- How should NASA balance priorities among the various disciplines supported by its Science Mission Directorate? Do you believe the proposed FY07 budget, given the overall level of spending allotted to science, does a good job of setting priorities across fields?

Questions for Dr. Berrien Moore

- What do you see as the most serious impacts on your field of the proposed slowed growth in the Science Mission Directorate? Clearly, it would be better to conduct more science than less, but what is the real harm in delaying specific missions? At

what point do delays or cutbacks become severe enough to make it difficult to retain or attract scientists or engineers to your field?

- Do you believe the decisions NASA has made concerning which missions to defer or cancel are consistent with the interim report of the National Academies Decadal Survey that you released? Given the FY07 budget request, do you see any need to change the process for the next Decadal Survey?
- How should NASA balance priorities among the various disciplines supported by its Science Mission Directorate? Do you believe the proposed FY07 budget, given the overall level of spending allotted to science, does a good job of setting priorities across fields?

Questions for Dr. Joseph H. Taylor, Jr.

- What do you see as the most serious impacts on your field of the proposed slowed growth in the Science Mission Directorate? Clearly, it would be better to conduct more science than less, but what is the real harm in delaying specific missions? At what point do delays or cutbacks become severe enough to make it difficult to retain or attract scientists or engineers to your field?
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